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Methods of Railroad Surveys On the Chicago and Northwestern Railroad

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METHODS OF RAILROAD SURVEYS ON THE CHICAGO AND NORTHWESTERN RAILROAD

...BY...

Joseph Carl Worrell

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE
IN CIVIL ENGINEERING

COLLEGE OF ENGINEERING
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OF Bachelor of Science in Civil Engineering.

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HEAD OF DEPARTMENT OF Civil Engineering

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Methods of Railroad Surveys on the Chicago and Northwestern Railroad.

Introduction.

The main purpose of this thesis is to present the methods followed by the Chicago and Northwestern Railroad on reconnaisance and preliminary and location surveys in the heavy timbered country of northeastern Wisconsin. The writer will also show wherein the methods can be recommended, and will try to point out in what way they could be improved.

The surveys were made on the Ashland division of the C. & N. W. Ry. in Vilas County, Wisconsin. The line of which the survey is to be described is composed of two branches, one thirty miles long and the other six. The longer one is itself a branch of a logging spur, and the shorter one

is a branch of the longer one. The new lines are to be used as logging roads until the timber is cleared. After that they are to be used for the light passenger traffic created principally by the resorts in this district. The logging spur leaves the main line of the C. & N. W. Ry. about six miles north of Rhinelander, and is five miles long.

Description of the Country.

The country was until quite recently covered with very heavy timber. Extensive areas have been cleared, however, and in some portions vegetables, hay, and oats are grown.

A considerable area of this part of Wisconsin is made up of small lakes, creeks, and swamps or peat beds. The lakes vary in area from one to ten square miles. The creeks usually flow from one lake to another, and are large enough for the passage of a row-boat. Portable row-to

this part of Wisconsin for their health or for pleasure, now the lakes and creeks are going to and from the summer resorts.

Besides the lakes spoken of, there were at one time numerous smaller lakes which are nearly or quite filled with accumulations of earthy deposits, washed in by rains, and with luxuriant growths of grasses and ferns which, becoming tangled and matted together. This matter constantly encroaching on the water, displaced the water until it finally attained almost to the level of the surrounding country. Instead of a sheet of water on the site of the lakes, now appears marshes or peat beds. The peat bed is often so soft that a person cannot walk on it; but sometimes they are more solid and afforded a thick growth of shrub-

bog such as pond, cedar, and tamarack. Soundings were taken with a 5-inch gas pipe and this test for "muck" was found to be powerful to pretty fair thick. One man could easily push the rod down, but it took three to pull it up. A good gravel bottom was always found below the "muck".

The ground is, in general, sandy and comparatively level, but there are portions which are rocky and broken. The highest hills probably do not exceed one hundred feet, but they are of such a character that it is not always easy to make railroad surveys.

Resources.

The water was next considered with the view when the preliminary reconnoissance was made. This was done by an engineer and two assistants who went over the country to

determine whether or not it would be profitable to build the road. The only instruments used were a pocket compass and barometer. The notes taken were chiefly with respect to the value of the timber, but some records were also made of elevations. A route was selected which would make the least grades in floating logs within reach of the line.

The reconnaissance force was made up in connection with the preliminary survey, by the engineer in charge, and two men, termed "Cruisers", who were timber experts. The distinguishing features of this survey were a more extended search for the proper topographical location of the line, and a more detailed examination concerning the amount and value of the timber.

The engineer in charge examined the country in advance

of the preliminary party, and gave instructions in regard to the route. The second examination of the timber was made by the owners who made an estimate of the kind, amount, quality, and value on each quarter-section. Their inspection covered the territory contiguous to the line, taking in all the timber for a distance of about two miles on each side. They followed the section lines, one reading the estimate of the amount of timber, the other pacing the distances. Their report stated the estimate of the three items for each quarter-section, forty, and also their opinion of the construction of the surveys very probably depended.

Preliminary Survey.

Both the compass and the transit were used in the preliminary survey. Two trains were taken to determine whether there

was any local attraction on the survey of this line, and the work was done under the assumption that there was no great amount. The duties of the various members of the party were similar to those of preliminary parties on other roads. The whole distance was first run with the compass, as it was thought that the work could be done more rapidly than with the transit. The instrument was an ordinary surveyor's compass mounted on a rod staff.

In order to connect the survey to known land-marks, "ties" were made to the section lines, which were "run out" by an experienced woodsman employed especially for this purpose. The section lines had been marked by posts and by blazed trees. The distances to the section corners were measured

by the chainmen.

On the line "plusses" for change of direction were measured to the nearest tenth of a foot. All other distances were measured to the nearest foot. Elevations were taken to the nearest tenth of a foot at stations and at abrupt changes in the surface, and to the nearest hundredth of a foot at turning points. Topographical features were taken only close to the line, and were estimated by the compass man.

After the compass preliminary was finished, the engineer in charge made out an estimate, and sent it to the chief engineer's office. While this estimate was being made, and while it was at the chief engineer's office, two days were spent in retracing the entrance line with the transit, the purpose being to check the angles,

and, incidentally the distances. When the compass and the transit were both used over the same line, the data obtained with the transit were used instead of that obtained with the compass. In the mountainous, the compass survey was found to be so inaccurate that it was necessary to retrace the old, or run a new line in such places.

Transit vs. Compass Preliminary.

Mr. Wellington, in his book on Economic Location of Railways, sums up his conclusions in regard to projecting preliminary lines with the compass in the following words: "This line also may, without any serious disadvantage, and with certain considerable advantages, be a compass line, if any time is thereby saved to be devoted to more important matters. The only advantage of a transit

line (and it is a slight one) as that it enables the map to be somewhat more accurately made. The located line does not coincide with the preliminary at any point, unless by accident, nor is there any intention that it should, nor is the location checked by the preliminary to any great extent, but by the profile and topography.

"An immeasurable prejudice exists in the minds of some engineers against compass lines, because of a false assumption that, because there is a certain lack of precision in it, the work is therefore inaccurate. On the contrary the chances of substantial accuracy in the final result, considered as a whole, are better with the compass than with a hasty transit line, it being assumed that no local attraction exists, since large cumulative

errors can not occur in the one case, while they can in the other. The reason for this is that the compass is run entirely by foresight, guided by the needle alone, while the transit is run entirely by backsight, from one accurate sight line ahead, and all angles are measured exactly by the vernier. It is very much more precise than a compass line, and is the only suitable method for running in location lines, and the only method now practiced, although it was not used in the earlier days of railroads. It has these disadvantages:

1. "It requires the cutting away of all obstructions, or tedious offsets around them, thus causing great loss of time and needless destruction of vegetation.

2. "An error in measuring or laying off an angle is cumulative, or continued indefinitely

in plotting the notes.

3. "The bright diamond are never used as such in properly conducted mapping, but have to be converted into bearings.

"On the other hand, there is to be said for the transit line, that it is not unfrequently the case that a time is saved by moving the compass instead of the transit, since the level limits the rate of progress in any case. When this is so, it is undoubtedly as well to run the more accurate line, and wherever there is danger of local attraction, it is the only proper one to run."

Mr. Shellington has made many miles of surveys for railroads and has probably used the compass under all conditions on preliminary surveys. He does not state whether he used the good stuff

or the tripod, but probably refers to both. Some of the deputy U.S. Washington's number for the compass do not appear to hold for the surveys under consideration here. These claims are: (1) The work can be done more rapidly with the compass than with the transit; (2) the local limits the use of compasses; and (3) inaccurate results is of slight importance.

1. The writer compared the average daily progress of both the compass and the transit parties on this survey and found no appreciable difference in the rate of the work.

2. The local deputy easily kept up with either the compass or the transit.

3. In rough country difficulty was often encountered if the preliminary survey and the paper locations did not check within 20 feet, and

it was hard to say at first whether the compass preliminary or the paper location were at fault. The paper location was checked by the transit, and the compass survey was found to be the more exact. Most of the data of the compass preliminary survey, except in the level country, and new data were taken with the transit. In most cases where the compass data were abandoned, the compass line was retraced with the transit; but in some places the preliminary was run. The compass was given a fair trial, but was unacceptable to the engineer could not be done with it.

Paper Location.

On this work an accurate map was of considerable importance. These lines were for

the greater part through timber which was so thick that it was impossible to see more than 200 feet in advance. On account of being able to see such a short distance, it was necessary to make a paper location which almost coincided with the preliminary line. The map was drawn to a scale of 400 feet to the inch. The compass notes were projected by bearings from the meridians and the transit notes by latitudes and departures. The P.C.'s and P.T.'s were located on the map and their station numbers given.

Mr. Wellington says concerning a paper location on a map made from a compass survey: "In running in the notes of such a paper location, the most experienced chief of party never expects that the notes can be followed in the field

without some slight correction at almost every curve. The profile will be found to be running too high or too low; errors in the field work and the topography will be discovered; many changes of alignment will suggest themselves, and in other ways changes will be made. Nevertheless the correspondence in general will be very close; so much so that it will be difficult to distinguish the paper and actual location profile. They may both be wrong and bad, but they are apt to agree with each other quite closely."

"After the preliminary work was finished, a map of the approximate location of the road, an estimate of the cost per mile, and the statement of the causes in regard to the nature of the timber was prepared and sent to the chief engineers office.

Location Survey.

Work was begun upon the location as soon as the estimate was accepted and returned from the chief engineer's office. The pencil location which accompanied the estimate was used by the party in the field as a guide in putting the line upon the ground. As a rule, the map was followed pretty closely, but wherever there was a chance for improvement, changes were made. As the location survey established upon the ground the lines to be constructed, it was necessary that such surveys should be more carefully done than in the preliminary surveys. The location surveys differed from the preliminary ones in that the curves were run in, and that the P.C.'s and P.T.'s of each curve were marked.

Three methods were employed in running the curves: the deflection method, offsets from the tangent, and offsets from chords. The deflection method was used for most of the heavy timber, and was used only in the clearing. The offsets from the tangent are the best for flat curves which do not exceed 9°, but in heavy timber the tangents must be cut, making the tangents. The offsets from the long chord were used to advantage in some curves in thick timber where the ground was level, but offsets from chords of 200 or 300 feet were used in hilly country when short sights were necessary.

If the engineer figured the intersection angle and length of curve from the paper location, the curve was run in by combining the deflection and chord-offset methods without locating

the P. I., which reduced the curvature required, but gave no check upon the accuracy of the work.

The purpose for which the road was to be used necessitated making the first cost as small as possible, therefore a great many curves were put in, and heavy grades were allowed. The maximum curve was ten degrees, and the maximum grade was two per cent. The minimum tangent distance between curves was 200 feet. No curves were provided, no reverse curves were put in, and there were only two compound curves on the whole survey.

Conclusion.

The engineer was not well enough acquainted with the situation to be of the most value to the company. He attempted to examine the country in advance of the party, but could not do this as carefully

as it should have been done

The instrumentman to the topography as best he could from his position on the line. The result was that only about 50 or 100 feet from the line was included and even this was estimated. A great deal of time and money could have been saved if a more careful topographical survey of the preliminary line had been made, even if it included territory only 200 feet out on each side.

Confirming the above statement concerning the taking of topography, Mr. Wellington says: "I can cite many instances of location successfully without further topographical tests, but only the geometrical test of a 'tie' to a preliminary, requires the nicest field and office work from the beginning to the end of the survey. It is, if error only in practice of degree. No one

would advocate anything but good work of the kind, but it is obvious that less precision is required, if it is fully understood and expected that the paper location will be topographically tested throughout, than if it is expected to be, in the main, a finality. The conclusion of the whole matter therefore is, that accurate topography for a certain narrow strip is a highly useful adjunct to practical location, which should never be omitted altogether and should generally be very carefully taken and studied; but it is in no way a safeguard against anything but minor errors of location, and is not a sufficient reliance for giving the best degree of perfection even to the details of alignment."

The management of the party on preliminary surveys

was poor, and the most valuable service to the company was not obtained. Had we enough men and instruments to form two parties, and had this been done, the amount of work could have been almost doubled. As it was, one party was too small for efficient service, and besides three or four men were left at camps who did practically nothing. Two parties could have made surveys within 300 or 400 feet of each other, and the engineer with the help of his assistant could have directed two surveys almost as easily as one. With two lines, the country could have been more thoroughly explored, and the projection of the paper location would not have been confined to such narrow limits.

Apparently, the engineer in

charge was competent and efficient. The importance of the work did not justify a high degree of accuracy, and the engineer could be commended for getting in needless time. He remembered things of importance along the line which the instrumentman had not recorded in the topography, and his suggestions were valuable both in projecting the paper location, and in putting the line upon the ground. From the beginning to the end, he was constantly making additional reconnaissances, and improvements wherever they were possible.

Considering the work as a whole, it was well done and deserved commendation. Some methods could have been improved, but others showed careful planning and were carried

out in a manner that would do credit to any engineer.

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